DEPARTMENT OF

# CIVIL ENGINEERING

## REPORT ON
## ANNUAL TESTING OF CONCRETE SPECIMENS (PHASES I TO IX) AT TREAT ISLAND, MAINE

for

CANMET
ENERGY, MINES AND RESOURCES CANADA

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**UNIVERSITY OF NEW BRUNSWICK**

FREDERICTON NEW BRUNSWICK CANADA

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## 1. INTRODUCTION

For 1988 The Department of Supply and Services awarded a contract to the University of New Brunswick covering the cleaning and testing of all concrete test blocks incorporating fly ash/slag/silica fume that are located at Treat Island, Maine. A copy of the contract is given in Appendix A.

## 2. IDENTIFICATION AND PREPARATION OF TEST SPECIMENS

The concrete test specimens at Treat Island are listed in Table I and a diagram of specimen location is presented on page 6. The prisms were first cleaned of seaweed and silt with metal scrapers and wire brushes. They were then identified by the markings on the stainless steel straps which had been previously placed around them.

## 3. PULSE VELOCITY MEASUREMENTS

The nondestructive examination of concrete prisms utilized a battery powered "Pundit" manufactured by C.N.S. Electronics Ltd. (London, England) Serial No. 84111848. The meter was calibrated to a reference bar at 26.0 microseconds, at the beginning and periodically throughout the testing. Transducers of fifty millimeter diameter were used with a coupling medium made from kaolinite and glycerol. Readings were taken at the center of each specimen and are recorded in Table II.

## 4. RESONANT FREQUENCY

Transverse resonant frequency measurements were performed using procedures and with equipment meeting the requirements of ASTM Designation C215-60. The results are recorded in

Table III.

Prior to and after visiting the site, the operation of the equipment was verified using a 1' x 1' x 3' prism and a 3" x 4" x 16" prism of concrete stored in the laboratory air. No change in reading was noted. Also the frequency readings of the oscillator was checked with the Department of Electrical Engineering standard and found to be in agreement with it. The mass of the driving unit had no noticeable effect on the frequency readings.

## 5. PHOTOGRAPHIC AND COLOUR SLIDE RECORD

Photographs of the individual specimens are in an enclosed envelope attached to this report. A set of slides has been stored in room B19, Head Hall, University of New Brunswick, Fredericton, for future reference. All slides and photographs were taken with a +1 setting on a Minolta XD11 camera.

## 6. VISUAL EXAMINATION

Using the rating system shown in Figure I the specimens were examined and the ratings and remarks recorded in Table IV. The evaluation was done independently by four people and in the few instances where differences of opinion

existed, a consensus was arrived at. A visual rating of two or greater was assumed to signify significant deterioration.

## 7. NATURE AND DEGREE OF DETERIORATION

For all air entrained concrete prisms the resonant frequency and ultrasonic pulse transit times indicate that the interior of the concrete is either not changing or is experiencing a very minor increase in stiffness with time. In some instances high transit times were noted and they are usually a consequence of problems of scaling on the surface of the specimens rather than any inherent reduction in strength of the concrete in the mass of the specimen. All evidence points to a surface type of deterioration and this can best be noted in the photographs and in the visual ratings. Based on ten years exposure, surface deterioration is clearly evident with a water to cement ratio of 0.6 and a cement replacement with slag of 45% or greater. With a water to cement ratio of 0.5, the replacement of 65% slag produces a noticeable deterioration as well. No difference in the performance of Type 10, 20 and Type 50 cement can be detected at this stage based on all specimens at the site.

After nine years exposure to sea water the specimens with a water to cement ratio of 0.6 and a replacement of cement in excess of 25% by both fly ash and slag produce significant deterioration. At a water to cement ratio of 0.4 and 0.5 the replacement of 60% of the

cement causes even greater deterioration. Again all evidence points to a surface type of deterioration as the ultrasonic pulse transit times and resonant frequency readings indicate no interior deterioration. Readings of transit time are variable from year to year and sometimes improve when a weak surface layer has come off.

After eight years exposure the lightweight concrete specimens with a cement content of 237 kg/m$^3$ (the lowest of all concrete placed by CANMET in this program) show significant deterioration for all types of cement and all levels of cement replacements.

Specimens containing lightweight aggregate show a pattern of deterioration that is different from normal weight concrete. With normal weight concrete there appears to be a potential for the mortar over the aggregate to come off in a sporadic fashion indicating a plane of weakness at the aggregate-cement paste interface. With lightweight concrete this is not noted and deterioration occurs by a uniform loss of the surface layer. The lightweight concrete specimen, HO3 has experienced top edge damage on the sea side as a result of a Corps of Engineer Lock Wall Specimen falling over on it.

Extensive deterioration of the non air-entrained specimens (SP3, SP4, and SP6) has taken place. There is nothing remaining of SP6 after five years. The results indicate that the addition of a superplasticizer tends to reduce the durability of a non air-entrained concrete.

There is the suggestion that the opposite might be true for air entrained concrete with the superplasticizer tending to make the air entrained concrete slightly more durable.The air-entrained specimens containing superplasticizers remain in good condition.

A general trend towards increasing surface deterioration can be noted in all specimens with a high water to cement ratio and a high percentage replacement of cement with slag. Specimens which contain both slag and fly ash show more surface deterioration than those which contain only slag for a given cement replacement value. However, specimens containing 80% slag do not show significant deterioration after four years exposure. Specimens containing silica fines have begun to show surface deterioration after four years exposure.

## 8. CONCLUSION

The replacement of up to 65% cement by slag has no apparent effect on the durability of concrete with a water to cement ratio of 0.4. A loss in durability is noted with a water to cement ratio of 0.5 with 65% replacement. With a water to cement ratio of 0.6 a significant increase in deterioration takes places at a 65% replacement level. In this latter case the deterioration is much more than just a surface phenomena and involves loss of aggregate particles.

Replacement of cement with both slag and fly ash produces severe deterioration when used at a 60% slag and

20% fly ash replacement rate even with water to cement ratios of 0.4.

It would appear that in many cases deterioration is on the threshold of proceeding rapidly and to obtain maximum information the specimens should be examined and studied closely over the next decade. During that time the effect of mix proportion, cement type and the role of supplementary cementing materials should become apparent.

← TO EASTPORT  NORTH ↑ TO BEACH  TO LUBEC →

**ROW 7**

| SECTION 7 | SECTION 18 | SECTION 32 | CANMET PHASE 1 1978 | | | | |
|---|---|---|---|---|---|---|---|
| BEAMS N7 through O16 | WESTEND NEW ENGLAND DIVISION 1 through 18 | REMR PROJECT GROUT MATERIALS | A01 through A13 | B01 through B13 | C01 through C13 | SP1 through SP6 | |

**ROW 6**

| SECTION 7 | | | | SECTION 19 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BEAMS MES FIBER H7 through M16 | P 7, 8 | CONT A, B | PIC 3, 2, 1 | MMA 3, 2, 1 | VE 3, 2, 1 | COA 2, 1 | SIC 3, 1 | 9x9x45 INCH BEAMS YOKED AND STRESSED BY THIRD POINT LOADING | |

**ROW 5**

| | CANMET PHASE 5 1982 | | | CANMET PHASE 8 1987 | | | CANMET PHASE 9 1987 | |
|---|---|---|---|---|---|---|---|---|
| | N01 through N04 | N01 through N04 | | X01 through X04 | Y01 through Y04 | | Z01 through Z08 | |

**ROW 4**

| | CANMET PHASE 5 1982 | | | | CANMET PHASE 2 1979 | | | | SECTION 12 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | O1 through O4 | P1 through P4 | Q1 through Q4 | R1 through R4 | D01 through D16 | E01 through E16 | F01 through F15 | | ROS 1 | ROS 2 | ROS 3 |

**ROW 3**

| | | MOBILE OIL 1985 | SECTION 27 | | | SECTION 12 | | SECTION 5 | | SECTION 21 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 11M through 42M | KC20-1, 2 | KC21-1, 2, 3 | ROS-1, 3 | ROS 4, 5, 6 | ROS 4A through ROS 6C | CERL 0 through CERL 41 | T2-1, 2, 3 | T4 through T9 |

**ROW 2**

| | CANMET PHASE 3 1980 | | | CANMET PHASE 6 1985 | | CANMET PHASE 7 1986 | | | CANMET PHASE 4 1981 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | G01 through G14 | H01 through H14 | I01 through I14 | S01 through S07 | T01 through T07 | U01 through U07 | V01 through V03 | W01 through W03 | J01 through J07 | K01 through K07 | L01 through L07 |

**ROW 1**

| SECTION 23 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 4 | 9 | 10 | 15 | 16 | 21 | 22 | 25 | 26 |

ARRANGEMENT OF TEST SPECIMENS ON RACK AT SEVERE WEATHERING EXPOSURE STATION, TREAT ISLAND, MAINE, AUGUST 1988

APPENDIX "A"

STATEMENT OF WORK

The Contractor and his staff shall travel to Treat Island and clean, test and inspect all of the fly ash/slag/silica fume concrete speciments that have been installed at Treat Island.

The Contractor shall carry out the following:

a) clean and label each concrete prism;
b) visual inspection and rating of each concrete prism;
c) provide one colour print of each specimen;
d) provide one colour slide of each specimen;
e) retag specimens where necessary;
f) determine pulse velocity for each prism;
g) determine resonant frequency for each prism;
h) provide CANMET staff with printed or video display of the readings in graphical form so that trends can be identified and correlated with onsite visual inspection;
i) display panels to be arranged on the deck at the time of the biannual inspection
j) provide 10 copies of the report on testing and inspection; the report shall also include a photographic record of the test specimens.

TABLE I - Mix proportions - Phase I

| Mix | Cement Type and Batch no. | | W : (C+R) Ratio | Batch Quantities (kg/m³) Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Type 10 | 1 | 0.4 | 158 | 396 | 0 | 0 | 0 | 590 | 1196 | 360 | 0 |
| | | 2 | | 160 | 292 | 97 | 0 | 0 | 576 | 1176 | 580 | 0 |
| | | 3 | | 178 | 318 | 97 | 0 | 0 | 553 | 1138 | 480 | 0 |
| | | 4 | | 181 | 319 | 106 | 0 | 0 | 546 | 1132 | 440 | 0 |
| | | 5 | | 176 | 443 | 0 | 0 | 0 | 558 | 1146 | 430 | 0 |
| | | 6 | | 176 | 243 | 199 | 0 | 0 | 556 | 1141 | 870 | 0 |
| | | 7 | | 175 | 243 | 199 | 0 | 0 | 554 | 1138 | 860 | 0 |
| | | 8 | | 176 | 243 | 199 | 0 | 0 | 556 | 1140 | 870 | 0 |
| | | 9 | | 177 | 445 | 0 | 0 | 0 | 558 | 1147 | 370 | 0 |
| | | 10 | | 176 | 154 | 287 | 0 | 0 | 553 | 1137 | 1130 | 0 |
| | | 11 | | 179 | 155 | 290 | 0 | 0 | 536 | 1102 | 1120 | 0 |
| | | 12 | | 180 | 156 | 286 | 0 | 0 | 538 | 1106 | 1120 | 0 |
| | Type 50 | 13 | | 157 | 392 | 0 | 0 | 0 | 600 | 1196 | 490 | 0 |
| | | 14 | | 158 | 395 | 0 | 0 | 0 | 604 | 1203 | 500 | 0 |
| | Type 10 | 15 | | 179 | 446 | 0 | 0 | 0 | 560 | 1152 | 390 | 0 |
| B | Type 10 | 1 | 0.5 | 161 | 329 | 0 | 0 | 0 | 641 | 1168 | 280 | 0 |
| | | 2 | | 161 | 244 | 82 | 0 | 0 | 638 | 1162 | 380 | 0 |
| | | 3 | | 161 | 247 | 82 | 0 | 0 | 644 | 1173 | 340 | 0 |
| | | 4 | | 151 | 231 | 77 | 0 | 0 | 651 | 1210 | 320 | 0 |
| | | 5 | | 161 | 320 | 0 | 0 | 0 | 668 | 1224 | 260 | 0 |
| | | 6 | | 166 | 183 | 150 | 0 | 0 | 629 | 1179 | 450 | 0 |
| | | 7 | | 166 | 183 | 150 | 0 | 0 | 629 | 1178 | 450 | 0 |
| | | 8 | | 167 | 183 | 150 | 0 | 0 | 630 | 1179 | 460 | 0 |
| | | 9 | | 167 | 335 | 0 | 0 | 0 | 656 | 1184 | 350 | 0 |
| | | 10 | | 166 | 116 | 215 | 0 | 0 | 634 | 1173 | 590 | 0 |
| | | 11 | | 167 | 117 | 217 | 0 | 0 | 640 | 1165 | 540 | 0 |
| | | 12 | | 168 | 118 | 219 | 0 | 0 | 645 | 1192 | 540 | 0 |
| | Type 50 | 13 | | 157 | 314 | 0 | 0 | 0 | 659 | 1203 | 350 | 0 |
| | | 14 | | 157 | 313 | 0 | 0 | 0 | 656 | 1198 | 350 | 0 |
| | Type 10 | 15 | | 166 | 331 | 0 | 0 | 0 | 648 | 1171 | 370 | 0 |

TABLE I (Cont'd) - Mix proportions - Phase I

| Mix | Cement Type and Batch no. | | W : (C+R) Ratio | Batch Quantities (kg/m³) Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | Type 10 | 1 | 0.6 | 170 | 282 | 0 | 0 | 0 | 688 | 1222 | 270 | 0 |
| | | 2 | | 167 | 209 | 70 | 0 | 0 | 674 | 1209 | 320 | 0 |
| | | 3 | | 168 | 209 | 70 | 0 | 0 | 676 | 1210 | 300 | 0 |
| | | 4 | | 159 | 199 | 66 | 0 | 0 | 643 | 1290 | 300 | 0 |
| | | 5 | | 160 | 276 | 0 | 0 | 0 | 650 | 1248 | 260 | 0 |
| | | 6 | | 160 | 147 | 120 | 0 | 0 | 650 | 1249 | 390 | 0 |
| | | 7 | | 158 | 145 | 119 | 0 | 0 | 641 | 1231 | 440 | 0 |
| | | 8 | | 158 | 145 | 119 | 0 | 0 | 642 | 1232 | 410 | 0 |
| | | 9 | | 160 | 266 | 0 | 0 | 0 | 647 | 1243 | 260 | 0 |
| | | 10 | | 160 | 94 | 174 | 0 | 0 | 638 | 1250 | 380 | 0 |
| | | 11 | | 160 | 93 | 173 | 0 | 0 | 636 | 1246 | 380 | 0 |
| | | 12 | | 161 | 94 | 175 | 0 | 0 | 643 | 1260 | 390 | 0 |
| | Type 50 | 13 | | 163 | 272 | 0 | 0 | 0 | 656 | 1270 | 260 | 0 |
| | | 14 | | 163 | 272 | 0 | 0 | 0 | 663 | 1274 | 260 | 0 |
| | Type 10 | 15 | | 161 | 268 | 0 | 0 | 0 | 652 | 1253 | 260 | 0 |
| SP | Type 10 | 1 | 0.5 | 167 | 334 | 0 | 0 | 0 | 654 | 1182 | 280 | 0 |
| | | 2 | | 166 | 332 | 0 | 0 | 0 | 649 | 1172 | 280 | 4720 |
| | | 3 | | 174 | 348 | 0 | 0 | 0 | 682 | 1232 | 0 | 6578 |
| | | 4 | | 174 | 349 | 0 | 0 | 0 | 683 | 1233 | 0 | 0 |
| | | 5 | | 165 | 335 | 0 | 0 | 0 | 647 | 1169 | 280 | 9730* |
| | | 6 | | 172 | 345 | 0 | 0 | 0 | 675 | 1219 | 0 | 16554* |

* Melamine-based superplasticizer was used

TABLE I (Cont'd) - Mix proportions - Phase II

| Mix | Cement Type and Batch no. | | W : (C+R) Ratio | Batch Quantities (kg/m³) Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D | Type 10 | 1 | 0.4 | 158 | 395 | 0 | 0 | 0 | 611 | 1256 | 390 | 0 |
| | | 2 | | 150 | 281 | 0 | 94 | 0 | 580 | 1192 | 960 | 0 |
| | | 3 | | 150 | 281 | 0 | 94 | 0 | 580 | 1192 | 960 | 0 |
| | | 4 | | 149 | 297 | 0 | 93 | 0 | 576 | 1184 | 950 | 0 |
| | | 5 | | 164 | 411 | 0 | 0 | 0 | 586 | 1198 | 370 | 0 |
| | | 6 | | 160 | 161 | 161 | 80 | 0 | 563 | 1152 | 1290 | 0 |
| | | 7 | | 160 | 161 | 161 | 80 | 0 | 564 | 1152 | 1290 | 0 |
| | | 8 | | 161 | 162 | 162 | 81 | 0 | 568 | 1162 | 1460 | 0 |
| | | 9 | | 164 | 411 | 0 | 0 | 0 | 582 | 1198 | 420 | 0 |
| | | 10 | | 165 | 83 | 247 | 82 | 0 | 564 | 1161 | 2130 | 0 |
| | | 11 | | 168 | 84 | 252 | 84 | 0 | 554 | 1138 | 1910 | 0 |
| | | 12 | | 168 | 84 | 252 | 84 | 0 | 554 | 1140 | 2070 | 0 |
| | Type 50 | 13 | | 153 | 384 | 0 | 0 | 0 | 551 | 1245 | 310 | 0 |
| | | 14 | | 151 | 379 | 0 | 0 | 0 | 542 | 1288 | 280 | 0 |
| | Type 10 | 15 | | 165 | 412 | 0 | 0 | 0 | 586 | 1191 | 300 | 0 |
| | Type 20 | 16 | | 148 | 370 | 0 | 0 | 0 | 530 | 1319 | 270 | 0 |
| | | 17 | | 141 | 355 | 0 | 0 | 0 | 510 | 1385 | 260 | 0 |
| E | Type 10 | 1 | 0.5 | 160 | 320 | 0 | 0 | 0 | 664 | 1208 | 160 | 0 |
| | | 2 | | 160 | 240 | 0 | 80 | 0 | 662 | 1211 | 590 | 0 |
| | | 3 | | 154 | 231 | 0 | 77 | 0 | 637 | 1213 | 640 | 0 |
| | | 4 | | 151 | 227 | 0 | 76 | 0 | 628 | 1255 | 570 | 0 |
| | | 5 | | 149 | 298 | 0 | 0 | 0 | 657 | 1260 | 150 | 0 |
| | | 6 | | 160 | 128 | 128 | 64 | 0 | 686 | 1163 | 640 | 0 |
| | | 7 | | 152 | 122 | 122 | 61 | 0 | 652 | 1185 | 610 | 0 |
| | | 8 | | 154 | 123 | 123 | 62 | 0 | 662 | 1202 | 580 | 0 |
| | | 9 | | 148 | 297 | 0 | 0 | 0 | 656 | 1257 | 180 | 0 |
| | | 10 | | 143 | 57 | 171 | 58 | 0 | 611 | 1246 | 770 | 0 |
| | | 11 | | 147 | 59 | 176 | 59 | 0 | 628 | 1241 | 680 | 0 |
| | | 12 | | 148 | 59 | 177 | 59 | 0 | 631 | 1247 | 680 | 0 |
| | Type 50 | 13 | | 152 | 304 | 0 | 0 | 0 | 657 | 1258 | 290 | 0 |
| | | 14 | | 138 | 275 | 0 | 0 | 0 | 666 | 1274 | 240 | 0 |
| | Type 10 | 15 | | 147 | 293 | 0 | 0 | 0 | 646 | 1208 | 190 | 0 |
| | Type 20 | 16 | | 149 | 297 | 0 | 0 | 0 | 629 | 1233 | 320 | 0 |
| | | 17 | | 133 | 264 | 0 | 0 | 0 | 695 | 1245 | 260 | 0 |

TABLE I (Cont'd) - Mix proportions - Phase II

| Mix | Cement Type and Batch no. | | W : (C+R) Ratio | Batch Quantities (kg/m³) Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F | Type 10 | 1 | 0.6 | 148 | 246 | 0 | 0 | 0 | 724 | 1247 | 140 | 0 |
| | | 2 | | 145 | 182 | 0 | 61 | 0 | 713 | 1229 | 440 | 0 |
| | | 3 | | 139 | 174 | 0 | 58 | 0 | 743 | 1179 | 490 | 0 |
| | | 4 | | 141 | 175 | 0 | 59 | 0 | 748 | 1187 | 460 | 0 |
| | | 5 | | 139 | 233 | 0 | 0 | 0 | 744 | 1179 | 210 | 0 |
| | | 6 | | 146 | 97 | 97 | 49 | 0 | 745 | 1166 | 540 | 0 |
| | | 7 | | 145 | 98 | 98 | 49 | 0 | 666 | 1239 | 490 | 0 |
| | | 8 | | 142 | 96 | 96 | 48 | 0 | 727 | 1215 | 480 | 0 |
| | | 9 | | 137 | 226 | 0 | 0 | 0 | 767 | 1147 | 190 | 0 |
| | | 10 | | 138 | 46 | 137 | 46 | 0 | 775 | 1160 | 540 | 0 |
| | | 11 | | 136 | 46 | 136 | 45 | 0 | 770 | 1152 | 500 | 0 |
| | | 12 | | 140 | 46 | 139 | 46 | 0 | 759 | 1181 | 510 | 0 |
| | Type 50 | 13 | | 135 | 225 | 0 | 0 | 0 | 745 | 1230 | 170 | 0 |
| | | 14 | | 135 | 224 | 0 | 0 | 0 | 743 | 1228 | 170 | 0 |
| | Type 10 | 15 | | 143 | 237 | 0 | 0 | 0 | 758 | 1202 | 150 | 0 |
| | Type 20 | 16 | | 126 | 209 | 0 | 0 | 0 | 729 | 1203 | 200 | 0 |
| | | 17 | | 129 | 216 | 0 | 0 | 0 | 721 | 1242 | 170 | 0 |

TABLE I (Cont'd) - Mix proportions - Phase III

| Mix | Cement Type and Batch no. | | Nominal Cement (kg/m³) | Batch Quantities (kg/m³) Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | Type 10 | 1 | 237 | 212 | 240 | 0 | 0 | 0 | 866 | 583 | 70 | 0 |
| | | 2 | | 217 | 241 | 0 | 0 | 0 | 873 | 586 | 71 | 0 |
| | | 3 | | 215 | 183 | 61 | 0 | 0 | 869 | 589 | 78 | 0 |
| | | 4 | | 219 | 184 | 62 | 0 | 0 | 870 | 589 | 75 | 0 |
| | | 5 | | 214 | 183 | 61 | 0 | 0 | 865 | 586 | 78 | 0 |
| | | 6 | | 210 | 241 | 0 | 0 | 0 | 871 | 585 | 71 | 0 |
| | | 7 | | 210 | 135 | 111 | 0 | 0 | 877 | 596 | 92 | 0 |
| | | 8 | | 207 | 133 | 109 | 0 | 0 | 864 | 587 | 94 | 0 |
| | | 9 | | 210 | 133 | 109 | 0 | 0 | 862 | 585 | 94 | 0 |
| | | 10 | | 204 | 239 | 0 | 0 | 0 | 864 | 581 | 78 | 0 |
| | | 11 | | 207 | 84 | 157 | 0 | 0 | 856 | 583 | 99 | 0 |
| | | 12 | | 209 | 85 | 158 | 0 | 0 | 868 | 592 | 94 | 0 |
| | | 13 | | 206 | 85 | 158 | 0 | 0 | 863 | 588 | 99 | 0 |
| | Type 50 | 14 | | 202 | 241 | 0 | 0 | 0 | 871 | 586 | 125 | 0 |
| | | 15 | | 196 | 243 | 0 | 0 | 0 | 879 | 591 | 135 | 0 |
| H | Type 10 | 1 | 356 | 215 | 356 | 0 | 0 | 0 | 777 | 589 | 102 | 0 |
| | | 2 | | 216 | 355 | 0 | 0 | 0 | 775 | 589 | 111 | 0 |
| | | 3 | | 222 | 268 | 90 | 0 | 0 | 764 | 590 | 121 | 0 |
| | | 4 | | 226 | 263 | 88 | 0 | 0 | 751 | 580 | 119 | 0 |
| | | 5 | | 220 | 266 | 88 | 0 | 0 | 758 | 584 | 120 | 0 |
| | | 6 | | 221 | 353 | 0 | 0 | 0 | 771 | 585 | 113 | 0 |
| | | 7 | | 220 | 198 | 162 | 0 | 0 | 750 | 587 | 155 | 0 |
| | | 8 | | 221 | 199 | 163 | 0 | 0 | 753 | 589 | 140 | 0 |
| | | 9 | | 220 | 199 | 163 | 0 | 0 | 754 | 590 | 133 | 0 |
| | | 10 | | 217 | 355 | 0 | 0 | 0 | 774 | 588 | 113 | 0 |
| | | 11 | | 209 | 129 | 239 | 0 | 0 | 747 | 592 | 191 | 0 |
| | | 12 | | 215 | 128 | 238 | 0 | 0 | 761 | 598 | 167 | 0 |
| | | 13 | | 226 | 122 | 227 | 0 | 0 | 768 | 594 | 159 | 0 |
| | Type 50 | 14 | | 200 | 352 | 0 | 0 | 0 | 759 | 595 | 194 | 0 |
| | | 15 | | 202 | 355 | 0 | 0 | 0 | 765 | 600 | 167 | 0 |

TABLE I (Cont'd) - Mix proportions - Phase III

| Mix | Cement Type and Batch no. | | Nominal Cement (kg/m³) | Batch Quantities (kg/m³) | | | | | | | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. | | |
| I | Type 10 | 1 | 475 | 222 | 473 | 0 | 0 | 0 | 661 | 571 | 151 | 0 |
| | | 2 | | 227 | 475 | 0 | 0 | 0 | 664 | 573 | 154 | 0 |
| | | 3 | | 224 | 360 | 129 | 0 | 0 | 653 | 574 | 195 | 0 |
| | | 4 | | 225 | 363 | 121 | 0 | 0 | 659 | 578 | 178 | 0 |
| | | 5 | | 225 | 357 | 119 | 0 | 0 | 667 | 580 | 187 | 0 |
| | | 6 | | 247 | 474 | 0 | 0 | 0 | 646 | 568 | 198 | 0 |
| | | 7 | | 247 | 261 | 214 | 0 | 0 | 616 | 565 | 231 | 0 |
| | | 8 | | 243 | 261 | 214 | 0 | 0 | 616 | 565 | 252 | 0 |
| | | 9 | | 239 | 271 | 221 | 0 | 0 | 638 | 575 | 279 | 0 |
| | | 10 | | 221 | 469 | 0 | 0 | 0 | 655 | 567 | 173 | 0 |
| | | 11 | | 214 | 166 | 307 | 0 | 0 | 628 | 565 | 266 | 0 |
| | | 12 | | 220 | 169 | 314 | 0 | 0 | 641 | 577 | 272 | 0 |
| | | 13 | | 217 | 167 | 310 | 0 | 0 | 635 | 571 | 269 | 0 |
| | Type 50 | 14 | | 211 | 465 | 0 | 0 | 0 | 648 | 576 | 351 | 0 |
| | | 15 | | 212 | 465 | 0 | 0 | 0 | 650 | 577 | 352 | 0 |

TABLE I (Cont'd) - Mix proportions - Phase IV

| Mix | Cement Type and Batch no. | | W : (C+R) Ratio | Batch Quantities (kg/m³) Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J | Type 10 | 1 | 0.4 | 178 | 440 | 0 | 0 | 0 | 586 | 1128 | 415 | 0 |
| | | 2 | | 178 | 440 | 0 | 0 | 0 | 586 | 1128 | 376 | 0 |
| | | 3 | | 179 | 442 | 0 | 0 | 0 | 589 | 1134 | 345 | 0 |
| | | 4 | | 170 | 318 | 0 | 106 | 0 | 529 | 1140 | 832 | 0 |
| | | 5 | | 163 | 305 | 0 | 101 | 0 | 507 | 1239 | 683 | 0 |
| | | 6 | | 170 | 319 | 0 | 106 | 0 | 530 | 1239 | 633 | 0 |
| | Type 50 | 7 | | 171 | 429 | 0 | 0 | 0 | 605 | 1214 | 367 | 0 |
| | | 8 | | 166 | 414 | 0 | 0 | 0 | 627 | 1171 | 427 | 0 |
| K | Type 10 | 1 | 0.5 | 174 | 348 | 0 | 0 | 0 | 639 | 1211 | 306 | 0 |
| | | 2 | | 173 | 346 | 0 | 0 | 0 | 635 | 1204 | 333 | 0 |
| | | 3 | | 173 | 345 | 0 | 0 | 0 | 634 | 1201 | 325 | 0 |
| | | 4 | | 163 | 244 | 0 | 81 | 0 | 625 | 1249 | 519 | 0 |
| | | 5 | | 160 | 240 | 0 | 80 | 0 | 632 | 1244 | 590 | 0 |
| | | 6 | | 160 | 241 | 0 | 80 | 0 | 622 | 1236 | 580 | 0 |
| | Type 50 | 7 | | 156 | 311 | 0 | 0 | 0 | 688 | 1226 | 337 | 0 |
| | | 8 | | 150 | 300 | 0 | 0 | 0 | 695 | 1246 | 324 | 0 |
| L | Type 10 | 1 | 0.6 | 159 | 263 | 0 | 0 | 0 | 730 | 1217 | 229 | 0 |
| | | 2 | | 160 | 260 | 0 | 0 | 0 | 737 | 1201 | 226 | 0 |
| | | 3 | | 158 | 262 | 0 | 0 | 0 | 731 | 1210 | 228 | 0 |
| | | 4 | | 148 | 183 | 0 | 61 | 0 | 742 | 1225 | 425 | 0 |
| | | 5 | | 149 | 184 | 0 | 61 | 0 | 760 | 1226 | 426 | 0 |
| | | 6 | | 148 | 186 | 0 | 62 | 0 | 751 | 1239 | 430 | 0 |
| | Type 50 | 7 | | 147 | 244 | 0 | 0 | 0 | 777 | 1241 | 255 | 0 |
| | | 8 | | 146 | 242 | 0 | 0 | 0 | 769 | 1229 | 286 | 0 |

TABLE I (Cont'd) - Mix proportions - Phase V

| Mix | Cement Type and Batch no. | | W : (C+R) Ratio | Batch Quantities (kg/m³) Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | Type 10 | 1 | 0.4 | 174 | 435 | 0 | 0 | 0 | 581 | 1120 | 435 | 0 |
| | | 2 | | 177 | 443 | 0 | 0 | 0 | 590 | 1137 | 407 | 0 |
| | | 3 | | 179 | 89 | 357 | 0 | 0 | 571 | 1146 | 1193 | 849 |
| | | 4 | | 177 | 88 | 354 | 0 | 0 | 567 | 1137 | 1906 | 1183 |
| N | Type 10 | 1 | 0.5 | 164 | 329 | 0 | 0 | 0 | 729 | 1147 | 143 | 0 |
| | | 2 | | 163 | 327 | 0 | 0 | 0 | 726 | 1143 | 177 | 0 |
| | | 3 | | 162 | 65 | 259 | 0 | 0 | 710 | 1130 | 456 | 333 |
| | | 4 | | 160 | 64 | 256 | 0 | 0 | 701 | 1115 | 389 | 343 |
| O | Type 10 | 1 | 0.6 | 154 | 260 | 0 | 0 | 0 | 751 | 1148 | 143 | 0 |
| | | 2 | | 155 | 257 | 0 | 0 | 0 | 754 | 1194 | 177 | 0 |
| | | 3 | | 151 | 260 | 202 | 0 | 0 | 724 | 1159 | 456 | 0 |
| | | 4 | | 153 | 259 | 204 | 0 | 0 | 733 | 1174 | 389 | 0 |
| P | Type 10 | 1 | 0.6 | 157 | 260 | 0 | 0 | 0 | 802 | 1101 | 203 | 0 |
| | | 2 | | 155 | 257 | 0 | 0 | 26 | 767 | 1087 | 368 | 957 |
| | | 3 | | 158 | 262 | 0 | 0 | 39 | 764 | 1105 | 468 | 2248 |
| | | 4 | | 157 | 259 | 0 | 0 | 52 | 742 | 1095 | 776 | 2894 |
| Q | Type 10 | 1 | 0.6 | 146 | 243 | 0 | 0 | 0 | 804 | 1125 | 196 | 0 |
| | | 2 | | 146 | 218 | 0 | 0 | 24 | 799 | 1125 | 417 | 1572 |
| | | 3 | | 146 | 206 | 0 | 0 | 36 | 790 | 1125 | 540 | 2525 |
| | | 4 | | 147 | 196 | 0 | 0 | 49 | 791 | 1135 | 672 | 2674 |
| R | Type 10 | 1 | 0.6 | 167 | 278 | 0 | 0 | 0 | 838 | 1129 | 0 | 0 |
| | | 2 | | 171 | 256 | 0 | 0 | 28 | 848 | 1159 | 0 | 3250 |
| | | 3 | | 170 | 240 | 0 | 0 | 43 | 837 | 1149 | 0 | 4236 |
| | | 4 | | 170 | 226 | 0 | 0 | 56 | 834 | 1149 | 0 | 4409 |

TABLE I (Cont'd) - Mix proportions - Phase VI

| Mix | Cement Type and Batch no. | | Nominal Cement (kg/m³) | Batch Quantities (kg/m³) Water | Cement | Fiber | Fly Ash | Silica Fume | F.A. | C.A. | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | Type 10 | 1 | 632 | 238 | 492 | - | 84 | 39 | 527 | 561 | 2410 | 5360 |
| | | 2 | | 243 | 502 | - | 85 | 40 | 493 | 573 | 1684 | 2882 |
| | | 5 | | 244 | 632 | - | - | - | 508 | 577 | 652 | 2740 |
| | | 6 | | 253 | 501 | 50.2 | 85 | 40 | 403 | 584 | 958 | 5196 |
| | | 7 | | 252 | 505 | 50.6 | 86 | 40 | 407 | 589 | 912 | 5990 |
| T | Type 10 | 1 | 509 | 227 | 408 | - | 70 | 33 | 587 | 606 | 594 | 2716 |
| | | 2 | | 228 | 408 | - | 69 | 32 | 582 | 601 | 657 | 2712 |
| | | 5 | | 230 | 509 | - | - | - | 612 | 600 | 361 | 2462 |
| | | 6 | | 245 | 391 | 48.8 | 66 | 31 | 570 | 598 | 518 | 3710 |
| | | 7 | | 237 | 394 | 48.2 | 67 | 32 | 563 | 590 | 630 | 4770 |
| U | Type 10 | 1 | 375 | 225 | 303 | - | 51 | 24 | 692 | 596 | 448 | 3792 |
| | | 2 | | 236 | 308 | - | 52 | 25 | 704 | 616 | 232 | 2533 |
| | | 5 | | 235 | 375 | - | - | - | 799 | 590 | 210 | 2146 |
| | | 6 | | 228 | 307 | 51.2 | 52 | 25 | 658 | 591 | 297 | 3165 |
| | | 7 | | 221 | 303 | 50.7 | 52 | 24 | 668 | 600 | 292 | 3736 |

TABLE I (Cont'd) - Mix proportions - Phase VII

| Mix | Cement Type and Batch no. | | Nominal Cement (kg/m³) | Batch Quantities (kg/m³) Water | Cement | Fiber | Fly Ash | Silica Fume | F.A. | C.A. | A.E.A (ml/m³) | Super Plasticizer (ml/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V | Type 10 | 1 | 500 | 140 | 500 | - | - | 30 | 700 | 550 | 800 | 4000 |
| | | 2 | | 140 | 500 | - | - | 30 | 700 | 550 | 800 | 4000 |
| | | 3 | | 140 | 500 | - | - | 30 | 700 | 550 | 800 | 4000 |
| W | | 1 | 400 | 145 | 400 | - | - | 30 | 660 | 635 | 750 | 2500 |
| | | 2 | | 145 | 400 | - | - | 30 | 660 | 635 | 750 | 2500 |
| | | 3 | | 145 | 400 | - | - | 30 | 660 | 635 | 750 | 2500 |

TABLE I (Cont'd) - Mix proportions - Phase VIII

| Mix | Cement Type and Batch no. | | W : (C+R*) Ratio | Batch Quantities (kg/m³) Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. |
|---|---|---|---|---|---|---|---|---|---|---|
| X | Type I | 1 | 0.38 | 132 | 347 | | 0 | | 864 | 1039 |
| | | 2 | 0.39 | 134 | 345 | | 0 | | 860 | 1034 |
| | | 3 | 0.31 | 109 | 157 | | 199 | | 827 | 1152 |
| | | 4 | 0.31 | 107 | 157 | | 199 | | 827 | 1153 |
| Y | Type I | 1 | 0.46 | 139 | 306 | | 0 | | 835 | 1074 |
| | | 2 | 0.46 | 139 | 304 | | 0 | | 830 | 1068 |
| | | 3 | 0.35 | 123 | 154 | | 195 | | 768 | 1129 |
| | | 4 | 0.35 | 124 | 156 | | 197 | | 775 | 1140 |

* R = fly ash by weight

TABLE I (Cont'd) - Mix proportions - Phase IX

| Mix | Cement Type and Batch no. | | W : (C+R*) Ratio | Batch Quantities (kg/m³) Water | Cement | Slag | Fly Ash | Silica Fume | F.A. | C.A. |
|---|---|---|---|---|---|---|---|---|---|---|
| Z | Type I | 1 | 0.50 | 164 | 328 | - | - | - | 789 | 1048 |
| | | 2 | | 170 | 339 | - | - | - | 781 | 1048 |
| | | 3 | | 155 | 233 | - | 78 | - | 781 | 1053 |
| | | 4 | | 152 | 228 | - | 76 | - | 764 | 1030 |
| | | 5 | | 164 | 295 | - | - | 33 | 772 | 1030 |
| | | 6 | | 163 | 291 | - | - | 33 | 762 | 1017 |
| | | 7 | | 159 | 159 | 159 | - | - | 758 | 1051 |
| | | 8 | | 160 | 160 | 160 | - | - | 763 | 1057 |

* R = slag + fly ash + silica fume by weight

TABLE II

Ultrasonic Pulse Transit Time Readings (microseconds)

| PRISM NO. | READING |
|---|---|
| A01 | 203.3 |
| A02 | 213.8 |
| A03 | 213.9 |
| A05 | 208.3 |
| A06 | 216.3 |
| A07 | 217.9 |
| A09 | 206.1 |
| A10 | 219.8 |
| A11 | 220.8 |
| A13 | 209.0 |
| B01 | 210.7 |
| B02 | 210.5 |
| B03 | 210.4 |
| B05 | 210.7 |
| B06 | 215.4 |
| B07 | 212.4 |
| B09 | 211.4 |
| B10 | 214.7 |
| B11 | 217.4 |
| B13 | 204.7 |
| C01 | 210.4 |
| C02 | 210.0 |
| C03 | 210.3 |
| C05 | 211.4 |
| C06 | 211.6 |
| C07 | 213.0 |
| C09 | 210.0 |
| C10 | 213.6 |
| C11 | 215.6 |
| C13 | 207.9 |
| SP1 | 208.6 |
| SP2 | 211.4 |
| SP3 | - |
| SP4 | - |
| SP5 | 206.2 |
| SP6 | - |

TABLE II (cont'd)

Ultrasonic Pulse Transit Time Readings (microseconds)

| PRISM NO. | READING |
|---|---|
| D01 | 202.7 |
| D02 | 210.1 |
| D03 | 208.8 |
| D05 | 200.0 |
| D06 | 228.4 |
| D07 | 221.7 |
| D09 | 202.7 |
| D10 | 235.8 |
| D11 | 234.4 |
| D13 | 207.2 |
| D16 | 203.7 |
| E01 | 204.4 |
| E02 | 210.6 |
| E03 | 215.7 |
| E05 | 209.1 |
| E06 | 222.9 |
| E07 | 219.2 |
| E09 | 207.8 |
| E10 | 231.6 |
| E11 | 227.4 |
| E13 | 205.5 |
| E16 | 208.4 |
| F01 | 211.8 |
| F02 | 213.3 |
| F03 | 217.8 |
| F05 | 214.1 |
| F06 | 225.4 |
| F07 | 222.8 |
| F09 | 216.8 |
| F10 | 248.6 |
| F11 | 251.5 |
| F13 | 212.4 |
| F16 | 218.3 |

TABLE II (cont'd)

Ultrasonic Pulse Transit Time Readings (microseconds)

| PRISM NO. | READING |
|---|---|
| G01 | 245.8 |
| G02 | 255.0 |
| G03 | 238.0 |
| G06 | 236.4 |
| G07 | 230.6 |
| G08 | 234.8 |
| G10 | 241.5 |
| G11 | 238.4 |
| G12 | 238.2 |
| G14 | 244.6 |
| H01 | 227.1 |
| H03 | 222.8 |
| H04 | 227.4 |
| H06 | 225.2 |
| H07 | 222.4 |
| H08 | 223.4 |
| H10 | 228.4 |
| H11 | 222.7 |
| H12 | 223.8 |
| H14 | 227.8 |
| I01 | 220.8 |
| I03 | 218.4 |
| I04 | 217.8 |
| I06 | 222.2 |
| I07 | 220.9 |
| I08 | 222.3 |
| I10 | 224.0 |
| I11 | 224.3 |
| I12 | 223.7 |
| I14 | 220.7 |
| J01 | 196.1 |
| J02 | 192.4 |
| J04 | 200.6 |
| J05 | 196.4 |
| J07 | 189.8 |

TABLE II (cont'd)
Ultrasonic Pulse Transit Time Readings (microseconds)

| PRISM NO. | READING |
|---|---|
| K01 | 193.4 |
| K02 | 197.3 |
| K04 | 192.8 |
| K05 | 197.4 |
| K07 | 196.9 |
| L01 | 199.1 |
| L02 | 201.3 |
| L04 | 200.0 |
| L05 | 195.8 |
| L07 | 202.4 |
| M1 | 194.8 |
| M2 | 193.4 |
| M3 | 214.4 |
| M4 | 213.2 |
| N1 | 199.3 |
| N2 | 194.2 |
| N3 | 218.4 |
| N4 | 220.7 |
| O1 | 198.6 |
| O2 | 200.6 |
| O3 | 217.5 |
| O4 | 216.0 |
| P1 | 202.2 |
| P2 | 203.8 |
| P3 | 199.7 |
| P4 | 205.3 |
| Q1 | 204.7 |
| Q2 | 202.4 |
| Q3 | 203.6 |
| Q4 | 208.1 |
| R1 | 201.4 |
| R2 | 190.6 |
| R3 | 193.7 |
| R4 | 198.6 |

TABLE II (cont'd)
Ultrasonic Pulse Transit Time Readings (microseconds)

| PRISM NO. | 1 TOP RIGHT | 2 TOP LEFT | 3 BOTTOM LEFT | 4 BOTTOM RIGHT | 5 CENTRE |
|---|---|---|---|---|---|
| S01 | 228.0 | 228.4 | 248.4 | 225.6 | 228.6 |
| S02 | 223.7 | 225.3 | 226.7 | 223.1 | 224.8 |
| S05 | 222.8 | 222.4 | 218.4 | 217.2 | 218.8 |
| S06 | 227.3 | 226.3 | 227.0 | 226.8 | 226.8 |
| S07 | 225.3 | 227.3 | 226.4 | 225.6 | 227.0 |
| T01 | 225.3 | 228.7 | 226.5 | 224.3 | 224.9 |
| T02 | 226.4 | 232.7 | 225.2 | 226.0 | 226.4 |
| T05 | 221.3 | 223.4 | 220.3 | 220.7 | 222.0 |
| T06 | 226.4 | 226.3 | 226.8 | 227.5 | 226.4 |
| T07 | 231.4 | 230.8 | 235.7 | 232.2 | 229.0 |
| U01 | 230.5 | 230.1 | 230.7 | 228.5 | 228.0 |
| U02 | 227.8 | 230.8 | 227.4 | 228.8 | 227.4 |
| U05 | 225.8 | 226.6 | 222.7 | 221.7 | 226.4 |
| U06 | 235.4 | 233.8 | 229.0 | 229.6 | 229.3 |
| U07 | 228.6 | 228.2 | 224.7 | 224.6 | 230.0 |
| V01 | 215.8 | 218.3 | 217.7 | 214.5 | 217.4 |
| V02 | 217.1 | 216.1 | 215.4 | 214.4 | 216.0 |
| V03 | 216.6 | 217.6 | 215.2 | 214.3 | 216.4 |
| W01 | 224.6 | 225.4 | 221.2 | 220.3 | 224.0 |
| W02 | 223.4 | 224.7 | 221.0 | 221.8 | 225.6 |
| W03 | 224.5 | 223.4 | 220.4 | 221.6 | 223.4 |
| X01 | 188.8 | 190.1 | 190.6 | 189.3 | 193.2 |
| X02 | 189.4 | 189.1 | 189.0 | 188.3 | 194.8 |
| X03 | 187.0 | 186.4 | 186.5 | 185.3 | 188.4 |
| X04 | 187.6 | 187.6 | 184.6 | 184.2 | 187.9 |
| Y01 | 195.7 | 195.6 | 190.7 | 189.7 | 197.4 |
| Y02 | 196.6 | 196.9 | 190.3 | 191.9 | 196.6 |
| Y03 | 193.1 | 194.8 | 189,0 | 188.2 | 192.8 |
| Y04 | 191.1 | 190.6 | 189.6 | 191.4 | 193.6 |
| Z01 | 207.8 | 206.3 | 205.6 | 205.7 | 208.5 |
| Z02 | 210.4 | 210.6 | 206.3 | 204.3 | 206.8 |
| Z03 | 214.8 | 213.7 | 208.8 | 208.8 | 214.1 |
| Z04 | 218.4 | 217.3 | 215.6 | 214.8 | 222.2 |
| Z05 | 213.8 | 214.8 | 215.8 | 209.6 | 223.9 |
| Z06 | 217.4 | 215.9 | 213.0 | 213.3 | 221.5 |
| Z07 | 216.0 | 217.3 | 214.5 | 211.4 | 224.7 |
| Z08 | 211.5 | 212.7 | 213.3 | 211.3 | 224.7 |

TABLE III

Resonant Frequency Readings

| SERIES | 1st HARMONIC FREQUENCY ($H_Z$) |
|---|---|
| A01 | 1210 |
| A02 | 1164 |
| A03 | 1159 |
| A05 | 1183 |
| A06 | 1164 |
| A07 | 1153 |
| A09 | 1183 |
| A10 | 1156 |
| A11 | 1160 |
| A13 | 1193 |
| B01 | 1144 |
| B02 | 1157 |
| B03 | 1165 |
| B05 | 1173 |
| B06 | 1159 |
| B07 | 1177 |
| B09 | 1151 |
| B10 | 1148 |
| B11 | 1091 |
| B13 | 1167 |
| C01 | 1149 |
| C02 | 1167 |
| C03 | 1169 |
| C05 | 1135 |
| C06 | 1173 |
| C07 | 1156 |
| C09 | 1141 |
| C10 | 1162 |
| C11 | 1171 |
| C13 | 1181 |
| SP1 | 1167 |
| SP2 | 1144 |
| SP3 | Damaged |
| SP4 | Damaged |
| SP5 | 1157 |
| SP6 | Missing |

TABLE III (cont'd)

Resonant Frequency Readings

| SERIES | 1st HARMONIC FREQUENCY ($H_Z$) |
|---|---|
| D01 | 1185 |
| D02 | 1137 |
| D03 | 1168 |
| D05 | 1210 |
| D06 | 1149 |
| D07 | 1152 |
| D09 | 1183 |
| D10 | 1082 |
| D11 | 1085 |
| D13 | 1163 |
| D16 | 1193 |
| E01 | 1185 |
| E02 | 1184 |
| E03 | 1135 |
| E05 | 1162 |
| E06 | 1124 |
| E07 | 1139 |
| E09 | 1184 |
| E10 | 1068 |
| E11 | 1079 |
| E13 | 1177 |
| E16 | 1151 |
| F01 | 1143 |
| F02 | 1145 |
| F03 | 1132 |
| F05 | 1127 |
| F06 | 1081 |
| F07 | 1088 |
| F09 | 1099 |
| F10 | 1026 |
| F11 | 1053 |
| F13 | 1142 |
| F16 | 1091 |
| G01 | 1012 |
| G03 | 1007 |
| G04 | 1042 |
| G06 | 1012 |
| G07 | 1077 |
| G08 | 1073 |
| G10 | 1005 |
| G11 | 1058 |
| G12 | 1057 |
| G14 | 1022 |

TABLE III (cont'd)

Resonant Frequency Readings

| SERIES | 1st HARMONIC FREQUENCY ($H_Z$) |
|---|---|
| H01 | 1084 |
| H03 | 1097 |
| H04 | 1078 |
| H06 | 1069 |
| H07 | 1098 |
| H08 | 1091 |
| H10 | 1071 |
| H11 | 1112 |
| H12 | 1105 |
| H14 | 1075 |
| I01 | 1100 |
| I03 | 1104 |
| I04 | 1107 |
| I06 | 1085 |
| I07 | 1108 |
| I08 | 1090 |
| I10 | 1074 |
| I11 | 1077 |
| I12 | 1098 |
| I14 | 1091 |
| J01 | 1230 |
| J02 | 1232 |
| J04 | 1190 |
| J05 | 1230 |
| J07 | 1284 |
| K01 | 1223 |
| K02 | 1184 |
| K04 | 1269 |
| K05 | 1246 |
| K07 | 1198 |
| L01 | 1198 |
| L02 | 1163 |
| L04 | 1205 |
| L05 | 1233 |
| L07 | 1175 |
| M01 | 1248 |
| M02 | 1241 |
| M03 | 1198 |
| M04 | 1183 |

TABLE III (cont'd)

Resonant Frequency Readings

| SERIES | 1st HARMONIC FREQUENCY ($H_z$) |
|---|---|
| N01 | 1211 |
| N02 | 1242 |
| N03 | 1197 |
| N04 | 1164 |
| O01 | 1197 |
| O02 | 1186 |
| O03 | 1154 |
| O04 | 1155 |
| P01 | 1164 |
| P02 | 1188 |
| P03 | 1207 |
| P04 | 1189 |
| Q01 | 1162 |
| Q02 | 1198 |
| Q03 | 1179 |
| Q04 | 1184 |
| R01 | 1115 |
| R02 | 1240 |
| R03 | 1260 |
| R04 | 1238 |
| S01 | 1084 |
| S02 | 1088 |
| S05 | 1104 |
| S06 | 1078 |
| S07 | 1071 |
| T01 | 1083 |
| T02 | 1076 |
| T05 | 1124 |
| T06 | 1078 |
| T07 | 1069 |
| U01 | 1080 |
| U02 | 1076 |
| U05 | 1098 |
| U06 | 1049 |
| U07 | 1085 |

TABLE III (cont'd)

Resonant Frequency Readings

| SERIES | 1st HARMONIC FREQUENCY ($H_Z$) |
|---|---|
| V01 | 1091 |
| V02 | 1089 |
| V03 | 1084 |
| W01 | 1122 |
| W02 | 1124 |
| W03 | 1121 |
| X01 | 1292 |
| X02 | 1294 |
| X03 | 1333 |
| X04 | 1356 |
| Y01 | 1260 |
| Y02 | 1261 |
| Y03 | 1282 |
| Y04 | 1306 |
| Z01 | 1181 |
| Z02 | 1166 |
| Z03 | 1129 |
| Z04 | 1111 |
| Z05 | 1134 |
| Z06 | 1137 |
| Z07 | 1128 |
| Z08 | 1143 |

TABLE IV

Rating of Specimens

| SERIES | RATING | REMARKS |
|---|---|---|
| A01 | 1 | |
| A02 | 1 | |
| A03 | 1 | |
| A05 | 1 | |
| A06 | 1 | Some loss of mortar |
| A07 | 1 | Some loss of mortar |
| A09 | 1 | |
| A10 | 1 | Some loss of mortar |
| A11 | 1 | Some loss of mortar |
| A13 | 1 | Some loss of mortar |
| B01 | 0 | |
| B02 | 2 | Some loss of mortar |
| B03 | 1 | Some loss of mortar |
| B05 | 1 | |
| B06 | 2 | Some loss of mortar |
| B07 | 2 | Some loss of mortar |
| B09 | 1 | |
| B10 | 3 | Some loss of mortar |
| B11 | 3 | Large spall-holds water, damage spreading to 80 x 120 ellipse |
| B13 | 1 | Some loss of mortar |

TABLE IV (cont'd)

Rating of Specimens

| SERIES | RATING | REMARKS |
|---|---|---|
| C01 | 2 | Slight end damage |
| C02 | 1 | Slight end damage |
| C03 | 3 | 2 mm loss of mortar |
| C05 | 0 | Slight end scaling |
| C06 | 2 | Some end damage |
| C07 | 3 | 5 mm loss of mortar |
| C09 | 1 | |
| C10 | 4 | 7 mm loss of mortar |
| C11 | 4 | 6 mm loss of mortar |
| C13 | 2 | 2 mm loss of water |
| SP1 | 2 | Some loss of mortar |
| SP2 | 1 | Some loss of mortar |
| SP3 | 9 | 20% of specimen remaining |
| SP4 | 8 | 60% of specimen remaining |
| SP5 | 2 | Some loss of mortar |
| SP6 | 10 | 0% of specimen remaining |
| D01 | 1 | Some loss of mortar |
| D02 | 1 | Some loss of mortar |
| D03 | 1 | 1 mm loss of mortar |
| D05 | 1 | 1 mm loss of mortar |
| D06 | 3 | 2 mm loss of mortar |
| D07 | 4 | 3 mm loss of mortar |
| D09 | 1 | 1 mm loss of mortar |
| D10 | 5 | 6 mm loss of mortar |
| D11 | 5 | 5 mm loss of mortar |
| D13 | 0 | Some loss of mortar |
| D16 | 1 | Some loss of mortar |
| E01 | 1 | Popout |
| E02 | 1 | Some loss of mortar |
| E03 | 1 | Some loss of mortar |
| E05 | 1 | Some loss of mortar |
| E06 | 4 | 4 mm loss of mortar |
| E07 | 5 | 5 mm loss of mortar |
| E09 | 1 | 1 mm loss of mortar |
| E10 | 5 | Aggregates exposed on sides |
| E11 | 5 | Aggregates exposed on sides |
| E13 | 1 | |
| E16 | 0 | |

TABLE IV (cont'd)

Rating of Specimens

| SERIES | RATING | REMARKS |
|---|---|---|
| F01 | 1 | Some loss of mortar |
| F02 | 2 | 1 mm loss of mortar |
| F03 | 2 | 2 mm loss of mortar |
| F05 | 1 | 1 mm loss of mortar |
| F06 | 6 | Loss of aggregates |
| F07 | 6 | Loss of aggregates |
| F09 | 2 | Some loss of mortar |
| F10 | 6 | Loss of aggregates |
| F11 | 6 | Loss of aggregates |
| F13 | 1 | Some loss of mortar |
| F16 | 1 | Some loss of mortar |
| G01 | 2 | Loss of 2 mm of mortar |
| G03 | 3 | Loss of 3 mm of mortar |
| G04 | 3 | Loss of 4 mm of mortar |
| G06 | 2 | Loss of 2 mm of mortar |
| G07 | 3 | Loss of 3 mm of mortar |
| G08 | 3 | Loss of 4 mm of mortar |
| G10 | 3 | Loss of 3 mm of mortar |
| G11 | 4 | Loss of 4 mm of mortar |
| G12 | 4 | Loss of 3 mm of mortar |
| G14 | 3 | Loss of 2 mm of mortar |
| H01 | 0 | Loss of 0 mm of mortar |
| H03 | 2 | Loss of 2 mm of mortar |
| H04 | 2 | Loss of 2 mm of mortar |
| H06 | 1 | Loss of 1 mm of mortar |
| H07 | 1 | Loss of 1 mm of mortar |
| H08 | 1 | Loss of 2 mm of mortar |
| H10 | 1 | Loss of 0 mm of mortar |
| H11 | 2 | Loss of 1 mm os mortar |
| H12 | 2 | Loss of 2 mm of mortar |
| H14 | 1 | Loss of 1 mm of mortar |
| I01 | 1 | Loss of 1 mm of mortar |
| I03 | 1 | Spall - 35 mm ø |
| I04 | 1 | Loss of 1 mm of mortar |
| I06 | 1 | Loss of 1 mm of mortar |
| I07 | 1 | Loss of 1 mm of mortar |
| I08 | 2 | Loss of 1 mm of mortar |
| I10 | 1 | Loss of 1 mm of mortar |
| I11 | 1 | Loss of 2 mm of mortar |
| I12 | 2 | Loss of 1 mm of mortar |
| I14 | 1 | Some loss of mortar |

TABLE IV (cont'd)

Rating of Specimens

| SERIES | RATING | REMARKS |
|---|---|---|
| J01 | 1 | |
| J02 | 1 | |
| J04 | 1 | Some loss of mortar |
| J05 | 2 | |
| J07 | 1 | |
| K01 | 1 | |
| K02 | 1 | |
| K04 | 2 | Loss of 1 mm of mortar |
| K05 | 2 | Loss of 1 mm of mortar |
| K07 | 1 | Some loss of mortar |
| L01 | 1 | |
| L02 | 1 | Some loss of mortar |
| L04 | 4 | Loss of 5 mm of mortar |
| L05 | 3 | Loss of 4 mm of mortar |
| L07 | 1 | 10 aggregates exposed |
| M01 | 1 | |
| M02 | 0 | |
| M03 | 1 | |
| M04 | 0 | |
| N01 | 0 | |
| N02 | 0 | |
| N03 | 1 | Some loss of mortar |
| N04 | 1 | Some loss of mortar |
| O01 | 1 | Some loss of mortar |
| O02 | 1 | Some loss of mortar |
| O03 | 3 | 2 mm loss of mortar |
| O04 | 2 | 1 mm loss of mortar |
| P01 | 2 | Some loss of mortar |
| P02 | 2 | Some loss of mortar |
| P03 | 3 | Some loss of mortar |
| P04 | 3 | Some loss of mortar |
| Q01 | 2 | 1 mm loss of mortar |
| Q02 | 2 | Some loss of mortar |
| Q03 | 3 | 1 mm loss of mortar |
| Q04 | 4 | 3 mm loss of mortar |
| R01 | 1 | Some loss of mortar |
| R02 | 2 | Some loss of mortar |
| R03 | 3 | Some loss of mortar |
| R04 | 5 | 4 mm loss of mortar |

All remaining specimens have a visual rating of 0 (zero).

TABLE IV (cont'd)

Rating of Specimens

| SERIES | RATING | REMARKS |
|---|---|---|
| S01 | 0 | |
| S02 | 0 | |
| S05 | 0 | |
| S06 | 0 | |
| S07 | 0 | |
| T01 | 0 | |
| T02 | 0 | |
| T05 | 0 | |
| T06 | 0 | |
| T07 | 0 | |
| U01 | 0 | |
| U02 | 1 | |
| U05 | 0 | |
| U06 | 0 | |
| U07 | 0 | |
| V01 | 0 | |
| V02 | 0 | |
| V03 | 0 | |
| W01 | 0 | |
| W02 | 0 | |
| W03 | 0 | |
| X01 | 0 | |
| X02 | 0 | |
| X03 | 0 | |
| X04 | 0 | |
| Y01 | 0 | |
| Y02 | 0 | |
| Y03 | 0 | |
| Y04 | 0 | |
| Z01 | 0 | |
| Z02 | 0 | |
| Z03 | 0 | |
| Z04 | 0 | |
| Z05 | 0 | |
| Z06 | 0 | |
| Z07 | 0 | |
| Z08 | 0 | |